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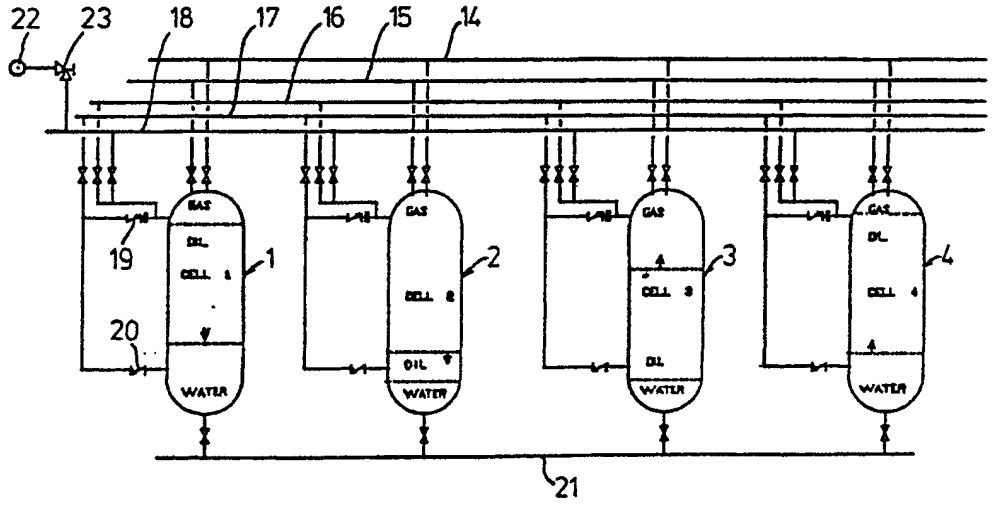
# (54) Separation of oil and gas from undersea wells

(57) At least two vessels (1-4) on the sea bed are used to separate oil, water and gas obtained from a well (22), their functions being changed in regular sequence to allow continuous production. Firstly mixed fluid from the well (22) is fed into a vessel (1) while displacing sea water, plus some separated water, from the bottom of the vessel and also venting gas from the top of the vessel to maintain the oil level constant. The gas pressure in the vessel is then used to displace the settled oil into another vessel (from vessel 2 to vessel 3 as shown). Finally sea water is admitted to force the oil from the other vessel (vessel 4 as shown) to a tanker on the surface, filling the vessel with water in preparation for the first step.

FIG. 2




At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1982.

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FIG. 1

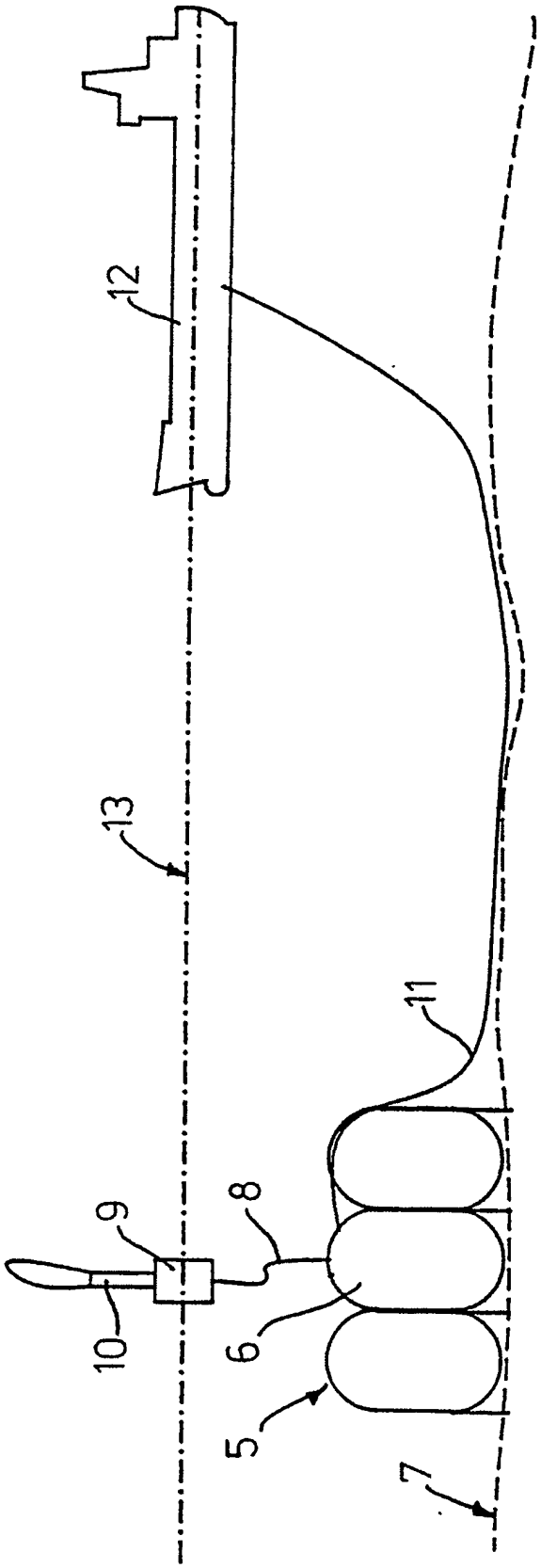
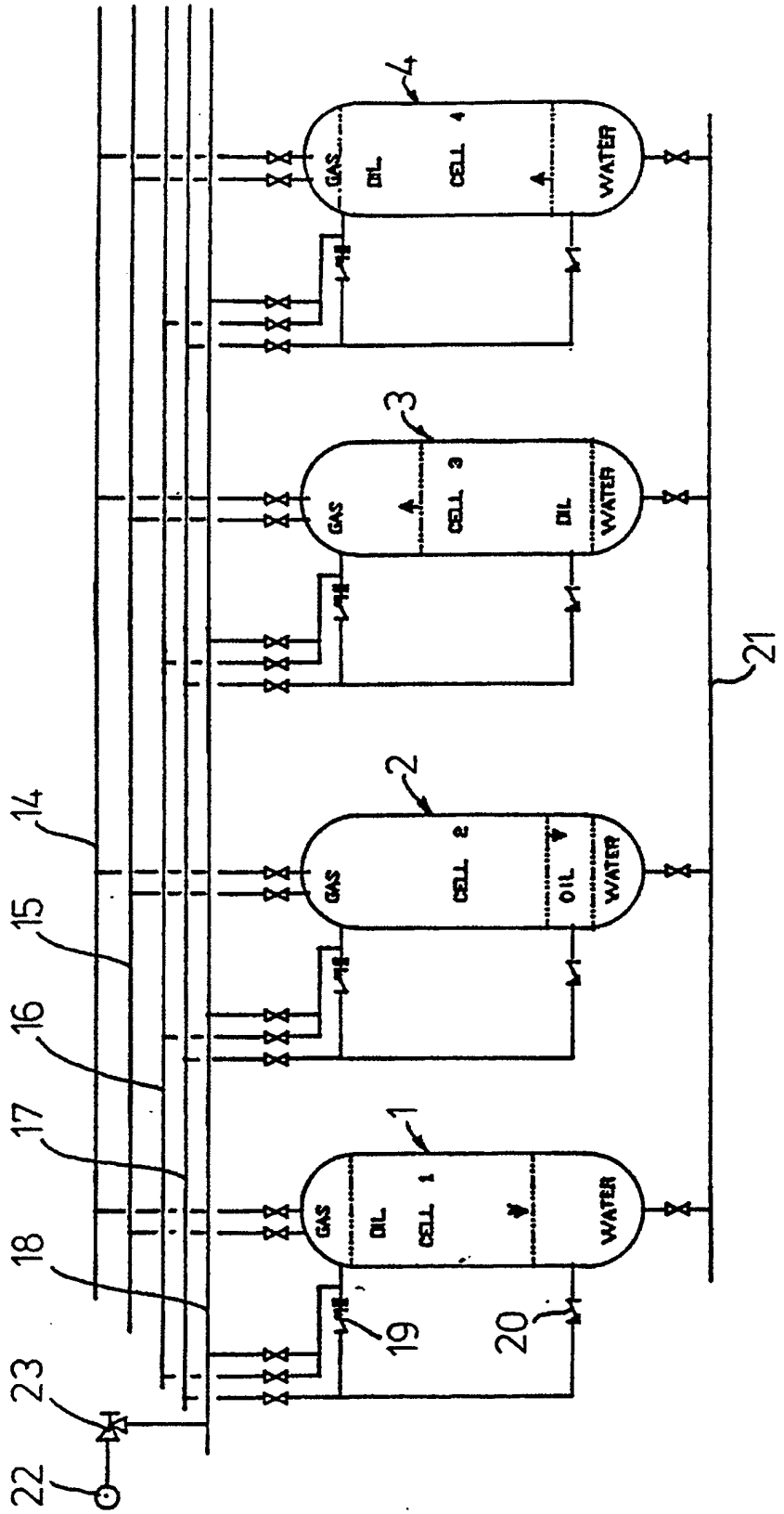


FIG. 2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A METHOD AND SYSTEM FOR TREATMENT AND TRANSPORT OF OIL AND GAS PRODUCED FROM WELLS ON THE SEA BED.

The present invention relates to a method and system for treatment and transport of oil and gas produced from wells on the sea bed.

According to one aspect of the present invention, there is provided a method for treatment and transport of oil and gas produced by wells on a sea bed, wherein oil and gas are separated in one or more vessels located on the sea bed before further transport in separate conduits, said method having a first cycle wherein the separation is performed in a first vessel, wherefrom water is discharged from a lower portion and gas from an upper portion, a second cycle wherein the separated oil is transferred from said first vessel to a second vessel by means of the pressure of the gas present in said first vessel and the gas released from the oil as the pressure decreases in said first vessel and a third cycle wherein the oil is forced out of said second vessel substantially by means of the pressure of the surrounding sea water, whereupon the method is repeated by utilizing said second vessel as the first vessel and vice versa.

It is possible to implement the present invention to establish a more economical system for well testing, early production or production. Embodiments of the invention may be utilized in several ways and provide products adapted to the requirements of the installation and the field, for example collecting the oil instead of burning it during well testing, separating off the water and separating gas and oil at high pressure before transportation and final treatment at another neighbouring platform (distance from 10 to 50 km), or stabilizing the oil with a sufficiently low vapour pressure in order to make it possible to transport it by tankers. Certain embodiments of the

invention may be adapted to include treatment installations for the gas e.g. for drying and recompression.

According to a preferred embodiment, at least four vessels

are used, so that the three cycles all may be performed concurrently in order to provide a generally continuous production, the various cycles not being tied to specific vessels but are shifting as these are emptied and filled.

The system was developed as a process of one or several stages in which a concrete storage tank is used, having several storage and treatment cells and being submerged on the sea bed. The oil may be transported from this storage tank via tankers calling at the field at regular intervals. The oil storage tanks must be large enough to hold the oil produced between tankers' calls.

The separators of the system may be arranged as sections or cells in the storage tank. They are connected to one or several wells which are preferably arranged in the centre of the storage tank. Underwater venting lines to the surface of the sea are connected to the separator stages and terminate in a buoy, a tower or such like on the surface. The discharge line for the oil to the tanker emerges from the top of the storage tank. Discharge of the oil may be based on the difference in density between water and oil, optionally with the added use of an auxiliary pump (booster pump).

The entire system may be ready constructed and tested on or by the shore and thereafter towed out to the field, whereafter ballast water is added to cause it to sink to the sea bed, optionally placed on a foundation of wells drilled in advance. The equipment may be de-ballasted which brings it to the surface, where it may be moved to a different location or towed ashore for major maintenance jobs.

It has been calculated that for fields which contain less than 30 million barrels of oil, the capital costs of the set-up described will amount to from 2 to 3 US Dollars per barrel of oil.

For better understanding of the invention, it will be described in some detail with reference to the exemplifying embodiment shown in the appended drawings, in which:

Figure 1 shows a principle arrangement of a facility for use with an embodiment of the present invention; and

Figure 2 shows schematically a process installation for performing an embodiment of the invention.

Referring to Figure 1, a concrete structure generally designated 5 is shown, having a central equipment cell or vessel 6, surrounded by separation/storage vessels or cells, which may be six in number. The concrete structure is situated on the sea bed 7 and is connected to one or more oil and gas producing wells (not shown).

By means of a flexible conduit 8, the concrete structure 5 is connected to a floating buoy 9, which has a flare 10 for burning gas. A second flexible conduit 11 connects the concrete structure to a tanker 12 at the sea surface 13, the tanker being suitably provided with a dynamic positioning system.

The process system shown in Figure 2 comprises four vessels or cells 1 to 4. The top of each cell is connected to a low pressure gas header 14 and a high pressure gas header 15 through suitable valves. Near the top, each cell is connected to a product header 16 and a production header 17. At the same level a transfer header 18 is connected through a non-return valve 19, allowing flow into the cell only. The transfer header 18 is also connected to the lower part of the cell, at this point through a non-return valve 20 allowing flow out of the vessel only. At the very bottom of each cell a water inlet/outlet header 21 is connected.

An oil well 22, which normally also produces some gas, is connected to the production header 17 through a throttle

valve 23.

The function of the installation is described hereinafter.

The process is sensitive to the ratio of oil to gas as well as the temperature of the oil. The installation is based on batchwise treatment of the oil and the gas and therefore requires fewer and simpler controls and adjustment mechanisms and a minimum of shut-off valves.

The first cycle runs in cell No. 1 of Figure 2. The oil flows from well(s) 22 drilled beforehand, through the throttle valve 23 to the production manifold or header 17 and into the water-filled cell 1. The pressure in the cell must be higher than the outside water pressure, whereby the oil forces the sea water and the water produced out of the cell. The pressure and the oil level are kept in check, and the level is constant in the upper part of the cell, while the oil/water level will shift downwards as production progresses. The gas is vented to the surface 13 of the sea through the flexible hose 8, alternatively released below the surface.

The second cycle runs in cells No. 2 and 3 of Figure 2. The oil is now forced from cell No. 2 into cell No. 3 by the gas present at the top of cell No. 2, and the gas released from the oil as the pressure gradually falls. The pressure in cell No. 3 must be sufficiently low to satisfy the transportation or exportation conditions, and the pressure in cell No. 2 must be sufficiently high to enable the oil to be lifted from the bottom of cell No. 2 to the top of cell No. 3. In cell No. 2, the oil/water level is constant and close to the bottom of the cell, while the gas level starts on top and moves towards the bottom. Cell No. 3 starts by being gas-filled with only small amounts of oil and water at the bottom, the oil level rises gradually and the gas is released on the surface of the sea.

The third cycle runs in cell No. 4 of Figure 2. This is the

discharge cycle and the pressure of the sea water is here used for forcing the oil out of the cell and up to the tanker 12. The sea water forces the oil out, and the oil/water level of the cell rises towards the top of the storage cell. When the cell is empty of oil, it is full of sea water, the way it was at the beginning of the first cycle. At sufficiently large ocean depths, there will be no need for cargo pumps, but at shallow ocean depths, these will be required because of insufficient pressure and consequently low capacity.

Between the first and the second cycle, several cells may be positioned to function in pairs as intermediate stages according to the same pattern as the second cycle, if the difference in pressure so permits, or the cells may be left individually full of oil as at the end of the first cycle.

The most natural manner in which to utilize additional cells is to position these as a store of finished products between cell No. 3 and cell No. 4 in Figure 2, where their treatment is completed and they only wait for transport capacity. Following discharge, these cells will again be ready to take over as cell No. 1 of the first cycle.

Although the invention has been described in terms of a specific embodiment, it will be understood that the invention is not limited to this embodiment but may be modified and varied in a number of ways by the skilled person.

CLAIMS

1. A method for treatment and transport of oil and gas produced by wells on a sea bed, wherein oil and gas are separated in one or more vessels located on the sea bed before further transport in separate conduits, said method having a first cycle wherein the separation is performed in a first vessel, wherefrom water is discharged from a lower portion and gas from an upper portion, a second cycle wherein the separated oil is transferred from said first vessel to a second vessel by means of the pressure of the gas present in said first vessel and the gas released from the oil as the pressure decreases in said first vessel and a third cycle wherein the oil is forced out of said second vessel substantially by means of the pressure of the surrounding sea water, whereupon the method is repeated by utilizing said second vessel as the first vessel and vice versa.

2. A method according to claim 1, wherein at least four vessels are used so that the three cycles all may be performed simultaneously in order to provide a substantially continuous production, the various cycles not being tied to specific vessels but being shifted as the vessels are emptied and filled.

3. A method according to claim 1 or 2, wherein the gas from the first vessel is led to a structure, such as a floating buoy, on the sea surface where it is burned or ventilated to the atmosphere.

4. A method according to any one of the preceding claims, wherein any water produced with the oil is separated in the first cycle and is forced out through the bottom of the vessel.

5. A method according to any one of the preceding claims, wherein in said first cycle the oil level is kept generally constant by means of a float valve regulating the release of gas from the vessel.

6. A method according to any one of the preceding claims, wherein the water forced out of said first vessel in the first cycle is led to a cleaning plant if its oil content is above a predetermined value.

7. A method according to any one of the preceding claims, wherein the oil forced out of said second vessel in the third stage is led to a tanker on the sea surface through flexible hose means.

8. A method according to claim 7, wherein the pressure in said second vessel during the second cycle is held at such a level that the oil being transferred to the tanker in the third cycle, has a vapour pressure which does not exceed the atmospheric pressure.

9. A method substantially as hereinbefore described with reference to the accompanying drawings.

10. A process installation for carrying out the method of any one of the preceding claims.

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